An Appendix to my Eſſay to.

GUNNERY.

OR,

Diſtances and Heights may be found Acceſſable or inacceſſable one mile two or three without the help of Geometrical

PROTRACTION.

Arithmetical or Trygonometrical

CALCULATION.

By a ſmall Inſtrument in the form of a two foot joynt Rule, with a ſlider and ſights,

Fitted to any mean capacity, that knoweth little of either *Writing* or *Reading*.

And for thoſe that are more Learned, there is a Secter Line of Cords to 180 Degrees, by which all Angles may be taken, either for *Diſtances* or *Surveying*, and a tangent Line for Altitudes, ſhewing more at large the multiplying of Fractions and the Rules of Practiſe in Decimals, with the way of extracting the *ſquare Root*.

Invented, Publiſhed, and the uſe thereof taught by

WILLIAM WALGRAVE

Dwelling at the two White Poſts *in* Newton ſtreet near little *Queen ſtreet in St.* Giles's *in the Fields.*

The Inſtrument is made and ſold, and the book ſhewing the uſe thereof, by Mr. *Walter Hayes* near the *Popes Head* Tavern in *More-fields*, LONDON.

London Printed by *H. Brugis* for the Author and *R. Pyne*, 1681.

R. 26

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TO THE READER.

The Author's Argument.

I Having been for many years, Acquainted, Concerned, and Imployed amongſt his Majeſties Gunners, and taught ſome of them ſuch parts of the Mathematicks as was neceſſary for them to underſtand, in the diſcharging the duty of a Gunner, in the finding of inacceſſable Diſtances, Heights or Altitudes, of Hills, Towers, Caſtles or other objects, which is neceſſary for a Gunner to know, for without the knowledge thereof, it will be impoſſible to give the Gunner true Elivation, to ſling a ſhot to any ſuch Object.

Therefore I well knowing that ſeveral of the Gunners, now belonging to his Majeſties Office of the Ordnance, many of them are but meanly verſed in the Arts Mathematical, and therefore unskil'd in the Calculation of Diſtances, Heights, *or* Altitudes, *by* Trigonometry.

For their ſakes, and at ſome of their Requeſts, I have contrived this neceſſary and helpful Inſtrument, the price will be but ſmall, although it be of great uſe; for you may lay a Gun to any any Degree of Mounture, as well by this Inſtrument as any other uſed in the Cylinder of the piece, Diſtances and Heights may be truly taken with it, without the uſe of Pen, Compaſſes, or Line of Cords, or any other help, but the Chain and marks to ſet up; I have formerly in my book of Decimal Arithmetick, and an Eſſay to Gunnery, Printed for the Author in 1677. *in page* 169 *and ſo forward, publiſhed a way to find inacceſſable Diſtances and heights, by one Multiplication; but I underſtand that was too hard for ſome, and therefore I now publiſh this Inſtrument, which I queſtion not but will be eaſy for all, with little help, ſo wiſhing you all happy proceedings I reſt yours,*

W. W.

CHAP.

CHAPT. I.

SECT. I.

The Deſcription of the Inſtrument, for the ſpeedy finding of an Acceſſable, Height or Diſtance without the help of Geometrical protraction or Arithmetical Calculation.

THis Inſtrument is formed with three pieces of Braſs, a Foot long, and three quarters of an inch broad each piece, whereof two of them are joynted together, like to a two foot joynt Rule; the third piece is fitted to ſlide very ſtedfaſtly upon either of the joynted pieces, and muſt alwaies keep at Right Angles, with the joynt piece it ſlideth on; and in the Center of this joynt muſt be placed a moveable ſight, with a ſlit in the middle thereof, perpendicularly over the Center of the joynt, and there muſt be four pieces of Braſs to ſtand perpendicular, about three inches high, at the other ends of the three pieces of braſs, and they muſt be of the ſame breadth with the long pieces, that they may ſerve for ſights on both ſides the two joynt pieces.

A deſcription of this Inſtrument, more at large by a ſmall figure in a Paper at the latter end of the book, to fold out, and lye in view, while

while the Book is read. I will deſcribe the parts of this Inſtrument by Letters, A is the Center of the joynt where the moveable ſlit ſight muſt ſtand, A M and B C is one of the pieces joyned together, and A N and D E is the other piece joyned, and in theſe two pieces the edge A B and A D is to be divided into inches, and every inch into ten parts, and the diviſions cut into the edge of the pieces.

The line A C and A F muſt be made a ſecter Line of cords to 180 degrees, their muſt ſights ſtand in the black places, at C B and D E the whole breadth of each piece, the one ſide thereof as B and D, muſt be uſed with the ſliding piece in taking of Diſtances or Heights, by ſuch perſons as are of mean capacity, and the other ſide of the ſights C and E is to be uſed in taking the quantity of any Angle; either for the taking of diſtances, Altitudes, or for Surveying of Land, K G H and L F I is the ſliding piece, and G H and F I muſt be divided into inches, and every inch into ten parts, and on the middle line thereof muſt be placed a Tangent from G H to 60 degrees, and at G F and H I muſt be placed two ſights upon the black places, the whole breadth of the ſliding piece, and the ſight G F muſt ſtand in a ſtraight line with the edge of the joynted piece A B, the ſliding piece lyeth under the two joynt pieces, as you may ſee by the figure, and the ſlider muſt be made to fit each joynt piece.

SECT II

SECT. II.

Shewing what ſorts of Meaſures are uſeful and neceſſary for this Inſtrument.

THe firſt ſettlement of our Engliſh Meaſures were taken from three grains of Corn to make one inch, and twelve of them inches to be one foot, and three foot to be one yard, and one yard and one quarter, or three foot nine inches to be one Ell, and five foot to make one Geometrical pace, or two ſteps; thus from the place where the right foot ſtood, to the place where it ſtepeth, is alwaies accounted to be a Geometrical pace or two ſteps; and any ordinary man may ſtep five foot at two ſteps, ſixteen foot and a half makes the Statute Perch, and the ſame length is called in ſome Countries a Loog, and in many places of *England* it is called a Pole, and at *London* and at other places it is called a Rodd, but in Surveying of Land, ſome Countries have cuſtomary meaſure or Wood-land meaſure, of Eighteen foot to the Perch or Pole, or what other name you pleaſe to call it; and ſome places twenty one, and other places twenty four foot to the Perch or Pole, but not confirmed by any Statute.

The moſt convenient thing to meaſure a-

ny meaſured Diſtance by, is Mr. *Gunters* Chain, which is divided into one hundred Links, and the whole length thereof is ſixty ſix foot, or twenty two yards, and thirteen Geometrical paces and two tenth parts of a pace, and four Perches, Poles, Rods, or Loogs, and twenty five Links makes one Perch or Pole, but the Linkes will not divide in the other parts.

Here I will acquaint you how many of the former meaſures make an Engliſh mile, 190080 grains of Corn makes one mile, 63360 inches makes the ſame, and 5280 foot is one mile, 1056 Geometrical paces the like, 320 Perches, Poles, Looges, or Rodds is one mile, 80 chains is alſo one mile.

66 Geometrical paces is one ſixteenth part of a mile, 132 is one eighth part, 264 is one quarter, 528 is half 792 is three quarters of a mile.

20 Perches is one ſixteenth part of a mile, 40 is one eighth, 80 is one quarter, 160 is a half, 240 is three quarters of a mile, 5 of Mr. *Gunters* chains is one ſixteenth part of a Mile, 10 chains is one Eight, 20 is one quarter, 40 is half, and 60 chains is three quarters of a mile, Feet, Yards, or Ells are not conſiderable.

It will be convenient in the taking diſtances with this inſtrument, (or any other) to

have

have the meaſured diſtance to be one third or one quarter, or thereabouts, of the diſtance of the object, for the longer your meaſured diſtance is, the truer will be the diſtance of any object taken.

If the object whoſe diſtance you would know be but 5 or 6 or 7 chains, it will be beſt to turn your meaſured diſtance into Geometrical paces, and two or three chains will be enough for your meaſured diſtance, betwixt ſtation and ſtation.

But if you judge the diſtance of the object to be about a quarter of a mile, 7 or 8 chains more or leſs, then turn your meaſured diſtrnce into Perches, and it will be convenient to take a meaſured diſtance of 8, 10 or 12 chains.

And when you judge the object to be diſtance from you, half or three quarters of a mile, little more or leſs, then accompt your meaſured diſtance from the firſt ſtation to the ſecond ſtation in chains, and 15. 18 or 20 chains will be convenient for your meaſured diſtance from ſtation to ſtation.

But when you judge the diſtance of the object to be more than one mile, and leſs than two mile and a quarter, then you are to count two chains for one, or take the half of your meaſured diſtance and uſe it as a whole meaſured diſtance, then the diſtance of the object found by the inſtrument muſt be

be doubled, if three quarters of a mile by the inſtrument, you muſt call it one mile and a half.

But when you would find a large diſtance, as three miles or more, then you are to treble your diſtance found on the inſtrument, for the diſtance of your object, and to take one third part of your meaſured diſtance, which may well be 60 chains, and one third part thereof is 20, and ſo you may proceed on with one quarter part of your meaſured diſtance, and then the diſtance of the object found on the inſtrument, muſt be four times ſo much, but you muſt be ſure of a large meaſured diſtance.

Here

Here is a convenient Table will help you to ſeveral things at the firſt ſight.

This Table hath four Columns, the firſt towards the left hand, hath the parts of an Engliſh mile, the ſecond is chains, and the third is Geometrical paces and parts anſwering to each chain; the fourth and laſt is Perches or Poles anſwering to the chains.

The uſe thereof is thus, having any meaſured diſtance from the firſt ſtation to the ſecond ſtation, in chains you may preſently have it in Geometrical paces and parts, or in Perches, which you have occaſion for, according to the diſtance of the object thus. If my meaſured diſtance were 5 chains, for which number I look in the ſecond columne under C and againſt it to the left hand is 16. which telleth me that 5 chains and 66 Geometrical

P.	C.	Pa.p.	per.
	1	13.2	4
	2	26.4	8
	3	39. 6	12
	4	52. 8	16
16	5	66. 0	20
	6	79. 2	24
	7	92. 4	28
	8	105.6	32
	9	118.8	36
8	10	132.0	40
	11	145.2	44
	12	158.4	48
	13	171.6	52
	14	184.8	56
	15	198.0	60
5	16	211.2	64
	17	224.4	68
	18	237.6	72
	19	250.8	76
4	20	264.0	80
	30	396.0	120
2	40	528.0	160
	50	660.0	200
3	60	792.0	240
4			

paces

paces or 20 Perches, in the laſt columne is one ſixteenth part of one Engliſh mile.

If Geometrical paces be moſt convenient for my uſe, then I take the 66, but if Perches be moſt convenient, then I take 20 for my meaſured diſtance.

Or if my meaſured diſtance be 10 chains, there I find 8 againſt it to the left hand, and 132 to the right hand which are paces, and to the right hand of 132 I find 40 which are perches, and the 8 ſheweth that any of theſe meaſures make one Eighth part of a mile.

But if the meaſured diſtance ſhould be 16 chains, their I find 5 which ſignifieth that 16 chains, 211 paces, and 2 tenths, and 64 perches, makes one fifth part of a mile; and at 20 chains is 4 placed, which denotes that 20 chains, 264 paces and 80 perches, is one fourth part or a quarter of a mile, and 2 ſignifieth that 40 chains, or 528 paces, and 160 perches, makes two parts or half a mile, and a gainſt $\frac{3}{4}$. is 60 chains 792 paces, and 240 perches, either of them is three quarters of the ſtatute or meaſured mile.

I hope I have ſufficiently declared the nature and uſe of numbers, proper for the uſe of this inſtrument; but it muſt be Practiſe that will beſt inform you what numbers to uſe; for you may as well bring the ſliding piece too near the joynt, as ſet it too far from it; for if you bring it too near the Angle will

be

be too ſharp or acute; but if the ſliding piece be too far off the joynt, then the joynt piece and the other end of the ſliding piece will not meet to ſhew the diſtance deſired.

SECT. III.

Of the uſe of the Inſtrument in taking of Diſtances, acceſſable or inacceſſable.

Firſt you muſt provide your ſelf with a ſtaffe five foot long or more, with a ſharp end ſhod with iron to ſtick in the ground, and at the upper end thereof a Sylinder head of Steell, Iron or Braſs, of good ſubſtance to hold a ſcrew to ſcrew the Inſtrument upon, Horizontal for the taking of diſtances, and there muſt be a convenience to ſcrew the inſtrument to the ſide of the head of the Staffe, that the inſtrument may ſtand perpendicular, for the taking of Heights or Altitudes.

There muſt alſo be provided a Line and Plummet to hang upon the top of the ſliding piece to ſet the inſtrument upright for taking of Heights.

Then you muſt get three or four Beconſtaves, like unto half Pikes, or the Archers Paliſades, which muſt bear your marks at the firſt and ſecond ſtation; the moſt convenient way that I do know of the uſing of them, is to ſet up one at the Right Angle at

B in figure, the ſecond and at O place another Staffe in a ſtraight line to B A, as ſuppoſe B to be the firſt ſtation, and A the ſecond ſtation; you muſt alſo be provided with a chain, ſuch an one as is deſcribed in the beginning of the laſt Section, and with ten ſticks, Arrows or Pins of great wyer, about a foot long a piece, then you will be fitted with all things neceſſary for taking of diſtances and heights or altitudes.

Now we may go boldly into the Field to try an Experiment, and for your better ſatisfaction, it will be convenient to ſet up a Becon-ſtaffe, with a white paper or handkerchief, as at C in figure the ſecond, then chuſe a place for your right Angle which may be at B in the ſame figure, and there ſet up your inſtrument with the outward end of your ſliding piece towards C, and the joynt towards A, the ſlider muſt for this triangle be put on the joynt piece A N and D E, then when you can ſee the mark at C by the edge of the ſights G H on the ſliding piece, then ſcrew the inſtrument faſt, if it be ſet level, then by the edge of the ſight at D and the ſide of the ſight G F, the ſlider ſtanding about the middle betwixt A and D, by thoſe two ſights place a Becon-Staffe at O directly behind the inſtrument, then take up the inſtrument, and ſet a Becon-ſtaffe in the ſame place upright where the inſtrument ſtood.

Then

Then take your chain and ten ſticks or pins what you have provided, and let a careful man lead the chain with the pins in his hand, in a ſtrait line towards A, the formoſt man cannot miſs of keeping of a ſtrait line, if he mind the Becon-ſtaffe at B. and the other at O, and lead the chain ſo that one Staffe do alwaies cover the other; and at every chains length prick down one of the ten pins, and he that followeth the chain muſt take them up, to keep account of the number of chains meaſured, then having meaſured 4 chains and 75 links, I come to A, and there ſet up the Inſtrument, as a ſecond ſtation, then turn the meaſured diſtance into Perches which is 19, then bring the ſlider within 19 Diviſions of the joynt, and there let it remain, then ſet the Inſtrument upright, and turne the inſtrument till you can ſee the Becon-ſtaff, at B in a ſtrait line through the moveable ſight at A, and by the edge of the ſight at D then ſcrew the inſtrument faſt, and move the piece A M and B C until through the ſlit of the moveable ſight at A, you can ſee the edge at B and the Becon-ſtaffe at C in a ſtrait line, and the ſight kept to its true place at B, then tell the diviſions from A towards B until you come to the place where it touches the ſliding piece, and you will find it to be 50, for the diſtance A C then count how many diviſions there is upon

on the ſliding piece, where it touches the joynt piece, and you will find 46 which is the diſtance from B to C.

And thus you have gained the diſtance from the firſt ſtation to the object, and alſo the diſtance from the ſecond ſtation to the object, or Becon-ſtaffe ſet up at C, and after the ſame manner you may find any greater diſtance.

SECT. IV.

How to take a diſtance about three quarters of a mile.

FIrſt put the ſliding piece about the middle of the joynt ſide A M and B C, then let figure the third be made uſe of for this Eperiment, here you may ſee the Right Angle lyeth contrary to the other, and therefore you muſt underſtand the ſliding-piece cannot be uſed on the right hand ſide of the joynt Rule, as the joynt is towards you, and the right ſide upwards, as in the laſt operation, therefore I muſt uſe the inſtrument as it is laid down on the Paper at the latter end of the book.

Here coming to ſome field that is large, I am deſired to find the diſtance of ſome object at C and not only from B nor from A but from them both, then having found a convenient

nient place to begin at, and where I can have a large meaſured diſtance, as from A to B, I ſet my inſtrument up at A and place it level, and turn the edges of the ſights of the ſliding-piece, marked in the figure with F and I, until I juſt find the object at C, then ſcrew the inſtrument faſt, and by the ſlit in the moveable ſight in the center, and by the edge of the ſight at B ſet up a Becon-ſtaff in a ſtrait line direct by the ſights before ſaid, and if there be room enough, let the Becon-ſtaff be two or three chains behind the inſtrument, then take up the inſtrument, and put a Becon-ſtaff in the room thereof and ſet it upright.

Then take the chain and pins, and meaſure forward towards B, the formoſt man that leadeth the chain is alwaies to ſtrain the chain gently, and not to put down a pin at the end of the chain, until he can ſee one Becon-ſtaff cover the other; then he may be ſure he is in a ſtrait line; alwaies he that followeth the chain, muſt have never a pin at the beginning, but ſtill gather them up where the leading man ſets them down, as he comes to them; and when the hindmoſt man hath gathered up all the pins, then let the leading man lead one chain after he hath ſtoock down all his pins, and ſtrain it and bring it in his ſtrait line and hold it there, or put his foot upon it until the hindermoſt man bring the ten pins to him that leadeth the

chain; then prick down one pin there and go forward again, and leave the hindmoſt man to ſtop the chain at the pin, and ſo go on again until you come to the next chain for every time the ten pins be out it is accounted ſo many chains, and great care muſt be taken in the changing of the pins, for fear you ſhould miſcount one chain at a change.

Then having meaſured to B two changes and ſix chains, which is 26 chains, for every change is ten pins or chains, then bring the ſliding piece of the inſtrument to 26 diviſions from the joynt, and there let it remain, then ſet up the inſtrument at the ſecond ſtation, and turn it about until through the ſlit of the moveable ſight, you can ſee the Edge of the ſight at B, and the beconſtaves in a ſtrait line; then ſcrew the inſtrument faſt to the ſtaff, and move the joynt-piece which beareth not the ſlider, until you ſee through the ſlit of the moveable ſight, and the Edge of the ſight at D, and the object at C, all in one ſtrait line, then you may count the diviſions on the ſliding piece 55 and about three quarters, which is the diſtance from A to C, then count the diviſions from the joynt, to the place where it touches the ſliding piece, which you will find to be 70, and ſome thing more, for the diſtance from B to C, which is three quarters of a mile, and

half

half a quarter, as you may ſee by the Table in Section the ſecond toward the latter end, for 60 chains is three quarters of a mile, and 10 chains is one Eight, or half a quarter of a mile.

and thus you may take a diſtance to one mile and half a quarter, without halfing or doubling of the inſtrument as it is now deſcribed, each piece to be a foot long, but thoſe that have a mind to have it made larger, it will be convenient then to have the diviſions larger as this is deſcribed to have 120 diviſions in one foot that may have but 100.

But if you would take a large diſtance, then let the meaſured diſtance be very large and take the one half thereof, thus if this meaſured diſtance had been 52 chains, then the half thereof would be 26, but you muſt alway remember that if you take half the meaſured diſtance you muſt double the diviſions found on the inſtrument; firſt take half the meaſured diſtance which is 26, then bring the ſliding piece to ſtand at 26 diviſions from the joynt, then as the inſtrument is fixed at your ſecond ſtation, take off the diviſions from the ſliding piece, all that are betwixt both the joynt pieces which is 55. 70. for A C which you muſt double and it makes 111 chains 40. 80. thereof makes a mile, and their will remain 31 which is more then a quarter and half a quarter of a mile, then the diſtance

from the joynt to the ſliping piece is 70 diviſions and more, which being doubled is 140 chains, which is juſt one mile and three quarters.

And if their be an occaſion for to find a larger diſtance, as you halfed and doubled, you may take one third, or one quarter of the meaſured diſtance, and repeat the diviſions found upon the inſtrument three or four times over; thus ſet the diviſions found on the inſtrument down three or four times one under another, and add them together, and their ſumms will be your diſtances deſired, and after this manner you may take diſtances of three or four miles.

SECT. V.

How you may find any Height or Altitude by this Inſtrument having the diſtance.

FOr the taking of Heights or Altitudes, the inſtrument muſt be ſcrewed to the ſide of the head of the ſtaff, that the inſtrument may ſtand upright inſtead of ſtanding level, and then ſet up the ſtaff at any known diſtance from the object, and a line and Plummet faſtned at the upper end of the ſliding-piece, as at H or I, that it may fall perpendicularly down the ſide, H K, or I L, to ſet the inſtrument upright, then ſet the ſliding-

piece

piece ſo much diſtance from the joynt, as the diſtance of the object was found to be, the ſtaff muſt be ſet down ſtedfaſtly in the ground, and indifferently upright, for the inſtrument may be ſet upright by the help of the ſcrew,

SECT. VI.

How to find the Height or Altitude of a very high Mountain at a great diſtance.

THere is a diſtance given, as A C 50 chains to find the Height of ſome Mountain, which is equal in height with the line C E, firſt bring the ſliding-piece of the inſtrument to 50 diviſions, from the center of the joynt, then ſcrew the inſtrument to the ſide of the head of the ſtaff, and fix the ſtaff in the ground, with the joynt of the inſtrument towards you, and the other end thereof directed ſtrait to the object at E, then with the help of the Line and Plummet, ſet the inſtrument level, that the ſliding-piece may ſtand perpendicular.

Then with your eye at the ſight in the center of the joynt, move the uppermoſt joynt-piece higher or lower, until through the ſight at the center, and by the lower ſide of the ſight D E, you can ſee the object at the other E, then count how many diviſions there is betwixt the lower joynt-piece and the lower

ſide

ſide of the upper joynt-piece, on that ſame ſide you ſet to 50, then count them diviſions, and you will find them to be 20, for the height of C E deſired.

And by reaſon you counted the diſtance in chains, this height is alſo chains, but by the Table in Section the ſecond, you may find how many Perches, or how many Geometrical Paces it is, for if you look for 20 in the ſecond Columne of the Table, you will find in the third Columne 264, and ſo many Geometrical paces is the height of that object; and in the laſt Columne of the Table againſt 20 and 264 is 80, which is the height of the object In Perches, Poles, Rods, or Loogs; and if any perſon deſires the height thereof in feet, they need no more then to multiply 264 by 5, and that product will give the number of feet to be 1320, and for thoſe that do not underſtand how to multiply, they may learn by my Decimal Arithmetick, beginning at page the ſixt and ſo forward.

Then look through the moveable ſight in the center until you can find the top of the object and the edge of the ſight at D, all in a ſtrait line, moving the upper joynt-piece higher or lower, till you find the top of the object, then if you have not ſtirred the inſtrument from its level, then the diſtance on the moveable or ſliding piece is the height

of

of the object; thus count the diviſions betwixt both the joynt pieces on the ſliding-piece and that is the height of the object, in ſuch meaſures as you meaſured your meaſured diſtance by, you may uſe which ſide of the ſliding-piece you pleaſe, if you will but remember that the ſame ſide that you intend to uſe, muſt alwaies be ſet to the diſtance given, either in finding of diſtances or taking of heights or altitudes.

In figure the ſecond I have the diſtance B and C given, as it was before found in Section the third, to be 4 chains 75 links, which put into Perches makes 56 Perches, then at C ſuppoſe a Tower or ſome other height, the top thereof to be equal to C D, and I ſetting my inſtrument at B would know the height thereof; thus the Inſtrument being ſcrewed to the ſide of the head of the ſtaff, fix the ſtaff in the ground with the joynt of the inſtrument towards you, and the other end directed to the object C D, and the ſliding piece ſtanding perpendicularly upright as the Line and Plummet ſhall direct you, then ſcrew the Inſtrument to the ſtaff, and place your Eye to the moveable ſight, and moveing the upper joynt-piece higher or lower, until you can ſee through the ſight in the center of the joynt the lower edge of the ſight D E, and the top of the object at D, in one ſtrait line, then if you have not moved

the inſtrument from its true perpendicular, the uppermoſt piece of the joynt-rule is ſet true; then either ſide of the ſlider ſet to 46 diviſions from the center, ſo much of that ſide of the ſliding-piece as is betwixt the joynt pieces, is the height of the object, and if you count thoſe diviſions, you will find them to be 6, and therefore the height of that object is 6 perches.

SECT. VII.

Here I ſhall declare ſome other wayes of taking of Diſtances and Altitudes by finding the quantity of Angles.

FIrſt to find the Angle C A B in figure the fourth, ſet the inſtrument up in the point A, and turn the joynt toward you, then ſet one of the joynt pieces to B, in ſuch manner that through the ſight at the center, you may ſee the outſide of the ſight at C, and a mark at B in a ſtrait line; then ſcrew the inſtrument faſt on the top of the head of the ſtaff, and turn the other joynt piece to C, and as the inſtrument ſtandeth, take the diſtance with a pair of Compaſs in the Cecter line of Cords, marked with A C and A E, from 60 to 60 on each piece, and that extent will reach from the center A towards C or E, to 56 degrees, which is the quantity of the

the Angle C A B, then with the chain meaſure from A to B 29 chains.

Then the inſtrument ſtanding on the top of the head of the ſtaff, ſet it up again at B as you did at A, then ſet one piece to C, in ſuch order, that through the ſight at the Center you can ſee the outer edge of the ſight C B, as the line A C is drawn, then ſcrew the inſtrument faſt, and turn the outermoſt ſide of the ſight D E upon the other joynt-piece as the line A E directs to a mark at A, as you can ſee in a ſtrait line through the ſight in the Center, then as the Inſtrument ſtandeth take the diſtance with a pair of Compaſſes from 60 degrees of one joynted piece to 60 degrees on the other joynted piece, then meaſure that extent from the joynt towards C or E, and you will find it to be 95 degrees, which is the quantity of the Angle A B C.

Then this you muſt obſerve, that the Angles of any plain Triangle, all three of them added together make 180 degrees, therefore having any two of them, the third is preſently found; thus add the two Angles given together, and ſubſtract that ſumm from 180 and what remains is the third.

The Angle C A B is 56 degrees, and the Angle A B C is 95 degrees, add them together thir ſumm is 151 degrees and 151 ſubſtracted from 180 there will remain 29 for the Angle A C B then having gained all the Angles

gles and one of the ſides, you may find the other two ſides by the doctrine of plain triangles.

Thus as the ſign of the Angle ACB 29. d. 00 is to the Logarithm of the ſide A B 29 ſo is the ſine of BA and C 56. 30. to its oppoſite ſide BC. 49 88.

03 14 42 9	
14 62 39 8	
99 21 10 7	
16 97 93 4	

And as the ſign of the Angle A C B 29. 00 is to the Logorithm of the ſide A B 29. ſo is the ſine of A B C 94. 30. to the Logarithm of the ſide A C. 59. 63.

03 14 42 9	
14 62 39 8	
99 98 65 9	
17 75 48 6	

And by theſe two operations, you have found the diſtance from B to C to contain 49 chains and 88 Links, and the diſtance from A to C is 59 Chains and 63 Links, and by the ſame way of working you may find any diſtance, uſing the chain and the inſtrament in the ſame manner as you did in this, and by the ſame way you muſt find the third Angle, which is alwaies the Angle at the object, and having all the Angles, and one ſide, which you muſt alwaies have a meaſured diſtance, to find any other diſtance by; what inſtrument ſoever you uſe.

When you have any Angle above 90 Degrees, you muſt ſubſtract it from 180 Degrees

grees and find the ſine of the Remainder, as the Angle A B C is 94 degrees 30 minutes, which being ſubſtracted from 180 will remain 85 degrees and 30 minutes, and you muſt uſe the ſine of 85. 30 inſtead of 94. 30. for there is no Cannon of ſines exceeds 90 degrees.

SECT. VIII.

Shewing how you may find the Angle of any Altitude, by the Tangent Line, in the middle of the ſliding piece.

FOr the taking the Angle of Altitude with this inſtrument, you muſt ſcrew it to the ſide of the head of the ſtaff, and fix the ſtaff in the ground, as you did in Section the fift and ſixt, and then ſet the ſliding-piece perpendicular, by the Line and Plummet, then move the upper joynt-Piece, until through the ſight of the center you can ſee the top of the object and the ſight D E in a ſtrait line.

It mattereth not whether it be the upper part or lower part of the ſight, for if you take the upper you muſt look what degrees the upper edge cutteth, and if it be the lower ſide of the joynt piece, then you muſt ſee what degrees the lower ſide cutteth on the tangent line, in the middle of the ſliding-piece.

Alwaies

Alwaies in the finding of any Altitude, you muſt firſt have the diſtance from the place of the object, to the place where you ſet up the inſtrument, as in Figure the fourth, the diſtance B C is 49 chains and 88 links, then I ſet up the Inſtrument at B with the joynt towards me, and bring the ſliding-piece to ſtand perpendicular, with the Line and Plummet, then moving the upper joynt-piece until I can ſee through the ſight at the center, the top of the object, and the lower ſide of the ſight at D in a ſtrait line, then I look what degrees it cuts on the Tangent-line, in the middle of the ſliding-piece, and I find the lower ſide cuts almoſt ten degrees, for you cannot diſcerne minutes by any inſtrument that is portable, but you muſt gueſs at them as near as you can, and I do gueſs this Angle to be 9 degrees and 50 minutes, you muſt alwaies bring the Tangent line right againſt T on the joynt piece.

Now having gained the Angle of Altitude, you may find the perpendicular height, or the length of the line C R, which is all one, by the Doctrine of plain Triangles or Trigonometry, as you found the diſtances in the laſt Section, for here you have all the Angles and the ſide B C, for in the taking of any Altitude, the taking of one Angle giveth you all the reſt, for alwaies the Angle at the bottom of the object will be a right Angle,

and

and therefore to find the Angle at the top of the object ſubſtract the Angle obſerved from 90 Degrees, and what remaineth is the Angle BRC, or the Angle at the top of the object, for if I ſubſtract 9 degrees 50 minutes from 90 degrees their will remain 80 degrees and 10 minutes, and ſo much is the Angle BRC 80, 10.

	d	m	
Then as the Sine of BRC	80.	10	0006428
is to it oppoſite ſide before	found		1697926
BC	49.	88	9232444
ſo is the ſine of the Angle obſer-			0936798
ved CBR	9.	50	

to the Logorithm of its oppoſite ſide CR 8. 65

So here you may ſee that by the adding of theſe three ſumms together, the fourth produceth the Logarithm of the height deſired.

But I would have you to underſtand that the firſt of theſe three numbers is not the Sine of 80. 10. but it is the Arithmetical complement thereof, for the Logorithm ſine is 9993572 and this ſubſtracted from 10000000 will remain 0006428, or without that trouble, you may do it in your mind thus, take every figure from 9, and ſet down the remainder, and the laſt figure ſet down its remainder from 10 and the work is done.

SECT.

SECT. IX.

Shewing how to take the Angles of an irregular field at figure the 5th.

THis will be but the ſame as you did in Section the ſeventh, in taking of B A C and A B C, for the taking their Angles, will be the ſame as taking any Angle round the field, firſt you are to remember, that where any Angle is expreſſed by Letters, alwaies the middle letter ſheweth the Angle or letter at the Angle, as in this figure the fifth, here is eight Angler, and as many ſides; and firſt to begin with this field, I ſhall ſet up my inſtrument at A, and a mark or becon ſtaff at B, and another at H, then ſet the outſide of the ſights of the joynt pieces, one of them to B and the other to H, by the moveable ſight in the center, then as the inſtrument is truly ſet to both the objects, at B and H, then with your compaſſes take the diſtance from 60 degrees of one joynt piece to 60 degrees of the other joynt piece, and that extent will reach to 115 degrees from A towards E or C which is the quantity of the Angle B A H which you muſt note down in your field book as you ſee in the Margent, and all the Angles that bend to the left hand, place them on the left hand of the chains and links, and thoſe that

	Angles	C	L	Angles
that bend towards the right hand place in the field-book on the right hand of the chains and links, as in the Margent, the Angle CDE 125 is placed on the right hand of the chain Line againſt 17 chains and 40 links, and as you took the Angle BAH leave a mark or	115.00	00	00	
	128.00	11	70	
	110.00	16	40	
		17	40	125.00
	91. 00	18	20	
	126.00	15	90	
	122.00	16	00	
	153.00	21	70	
		24	00	

beacon at A, and meaſure to B, which is a 11 chains and 70 links, which you muſt place in the field-book under C and L, for C ſignifieth Chains, and L ſignifieth Linkes, then ſet the inſtrument up at B and place another beacon at C, then as at A turn your joynt pieces both waies, one to A and the other to C, and take the diſtance from 60 to 60, as you did before, and that meaſured from the center, will reach to 128 which is the quantity of the Angle ABC, then place 128 into the field-book, and ſet up a becon at B, and meaſure from B to C 16 chains and 40 links, which muſt be alſo placed in the field-book, and the inſtrument ſet up at C and a becon placed at D, then one joynt piece turned to B and the other to D, the Angle BCD will be found to be 110 degrees, which muſt alſo be placed in the field-book, then ſet up a be-

con

con at C and meaſure from C to D 17 chains 40 links, which you are to place in the field-book in its proper place, then ſend a becon to E and ſet up the inſtrument at D, and turn one joynt piece to C and the other to E and take the quantity of that Angle as you did the others, and the Angle CDE will be found to be 125 degrees which you muſt place in your field book on the right hand of the middle columne, to ſignifie the Angle bendeth the contrary way to all the reſt of the Angles, then leave a becon at D, and meaſure from D to E 18, 20. and place it in the field-book under C L, then are half the Angles taken and half the ſides meaſured, and by the ſame way of working you may take the reſt of the Angles and ſides and place them in your field-book as beforegoing you may ſee.

SECT. X.

Shewing how to prove the truth of the Angles taken round about the field, in the laſt Section.

BOth Mr. *Wing* and Mr. *Leybourn*, ſhew you how to prove the truth of the Angles taken, if all the Angles bend inwards; but in this plot here is one bendeth outward, and therefore you muſt take the complement of the outward Angle to 180 degrees, and add the complement to the other ſeven Angles

gles, and that muſt be equal with 180 multiplyed by five, for alwaies the complement of any Angle loſeth the Angle, and maketh it become a ſtrait line, for in the Angle C D E in figure the fifth, that Angle is 125, which taken from 180 there will remain 55, which will make both the Angles at C and E, and C D E will be a ſtrait line, from C to E, and therefore the Angle wholly loſt; and for that reaſon you muſt in this caſe account the field to have but 7 Angles, and this rule is general, if the Angles be all inward Angles, count the number of the Angles, and from that number ſubſtract 2 and multiply 180 by that remainder, and that will be equal to the ſumm of all the Angles added together, but if there be any outward Angles, add the complements thereof and that will be equal to the number of inward Angles leſs by two; thus in the figure above ſaid the ſumm of the ſeven inward Angles and the complement of the outward Angle is 900, and if you ſubſtract two from the ſeven inward Angles thus, two from ſeven and there remaineth five, and 180 multiplyed by 5 produceth 900 as before; and by this proof you may know that the Angles are truly taken, and the ſame you may do in all other figures.

And for thoſe that have a mind to plot the ſame, need have no other protracter, but the inſtrument it ſelf, for firſt draw a line at

pleaſure, to repreſent the line A H, and from the diviſions on either of the pieces, with your Compaſſes take off 24 parts, and ſet from A to H, which will be the length of that line A H, then from the cecter line A C or A E, from A extend the Compaſſes to 60 degrees, and ſetting one foot in the Angular point B A H make a ſweep, from the line A H until it croſs the line A B continued, then take off 115 degrees from the ſame ſector line, and ſet one foot of the Compaſſes in the beginning of the ſweep from the line A H, and with the other make a croſs at the other end of the Arch at the ſame diſtance of 115 degrees.

Thus having taken from the ſecter line the diſtance from the center to 60 degrees, with that extent with one point ſet in A make the ſweep H I, then take from the ſame ſector line 115 degrees, and make a ſmall croſs at I, then take from either of the lines of inches and tenths a 11 of thoſe diviſions, and as neer as you can gueſs 70 parts of another diviſion, and ſet it from A to B, and there make a ſmall ſweep, then lay a Rular from A to the croſs at I, and draw the line from A to B, then will the line H A and A B and the Angle B A H be compleated, and truly plotted, then extend the line B A to the left hand of A, and the line B C to the right hand of C when you come to know it, then with

60 degrees, or the diſtance A I, ſet one foot of the Compaſſes in B and make a ſweep from K the extended line on the left hand of A at pleaſure, then take from the ſector line of Cords 128 degrees, and ſet one foot of the compaſs in K, and with the other point croſs the line at L, then from the inches and tenths take off 16 diviſions and 40 parts of another as near as you can gueſs, then lay a rule from B to croſs at P, and with your Compaſſes prick down the diſtance B C, and draw it black, and continue that line pricked to the right hand of C, as above directed, then there will be three ſides, and two Angles compleated and truly plotted, and by the ſame manner of working you may plot all the other ſides and Angles, which will exactly meet at H, if your work be truly done.

Adverti ſement, firſt it will be very convenient to make the plot of this field a great deal larger, for as it is now plotted every inch is ten chains, which maketh 40 Perches in one inch, and it will be convenient to plot it, at 4, 6, 8 or 10 perches in one inch; it will be very neceſſary for you to have ſeveral ſcales made upon a piece of Braſs or Box, about 15 inches long and two inches broad, that there may be fourteen or ſixteen ſeveral ſcales convenient to draw the Plot of any bigneſs, ſome of them divided Diagonally to anſwer to Mr. *Gunters* chain and each link there-

of, and the other common decimal ſcales that you may be fitted for the laying down of a plot to every two Perches, for the more convenient fitting the paper parchment or Velum that you are to draw the plot upon, to have handſome room.

And at the lower end of ſome of the decimal ſcales, let there be placed two or three or more lines of cords, one of the radius of one inch to help you in ſmall drafts plotting as figure the fifth, and another of one inch and a half Radius, and both theſe need be divided but to 60 degrees and two other lines of cords, one of two inches radius, and the other of two inches and an half, and the leſſer of them divided into 90 degrees, and the other divided as the ſecter line of the inſtrument.

The uſe of theſe lines of cords is the ſame in plotting as the ſecter line of the inſtrument only for ſmaller drafts, and in the two ſmall lines of Cords that are divided into 60 degrees, you are firſt to take off with your Compaſſes the whole length thereof, then ſet one foot of the Compaſſes in the point A and with the other make the ſweep M N, then without moving the Compaſſes cloſer or wider, meaſure from M in the arch line towards N which will reach to Q, then take the diſtance from Q to N with your Compaſſes and meaſure it on the ſame line of Cords and you will

will find it to be 55 degrees, then add 55 and 60 together and it will make 115 as before, for the quantity of the Angle H A B; but if the line A B had not been drawn, then you are to meaſure of M Q 60 degrees, and ſubſtract it from 115 degrees and there will remain 55 degrees, then take out of the ſame line of cords 55 degrees, and place one point of the Compaſſes in Q, and croſs the Arch line M N, and through that croſs draw the line A B its juſt length as before, then with the ſame 60 degrees ſet one foot of the compaſſes in B, and make the ſweep O P, then the points of the compaſſes not moved, ſet one foot in O, and meaſure along the arch line O P which will be two turns of the compaſſes, which is 60, and 60 added together maketh 120 which wanteth of the quantity of the Angle A B C 8 degrees, then make a croſs at the end of the two ſixties and take from the ſame ſcale 8 degrees, and it will reach from the croſs to P, and there make another croſs, then lay a ruler from B to that croſs, and draw the line B C its true length, and if you do the ſame kind of work at C D E, and ſo round the Plot, you will have a true plot of the field, and each Angle and ſide thereof.

CHAP.

CHAPT. II.

MVSEVM BRITAN

SECT. I.

Shewing more at large the way of Multiplying of the fractions of the foot Mr. Gunters *chain or Engliſh coyn.*

IF one half of a Foot be multiplyed by one half, it will produce but one quarter of a Foot, either Decimally or Vulgarly, for in Decimals half a foot is 5 or 50 the whole foot being either 10 or 100, then if 5 be multiplied by 5 it will produce but 25, and 25 is but one quarter part of an 100, and if 50 be multiplyed by 50, the product thereof is but 2500 which is one quarter of 10000, and by vulgar Arithmetick half a foot in length is 6 inches, and 6 times 6 is 36 which is but one quarter of 144 and the chain the ſame.

And in Engliſh coyn, one half of a pound, which is ten ſhillings being multiplyed in it ſelf by Decimals will be the ſame with the foot, for one tenth part of twenty ſhillings is two ſhillings, then 5 tenth parts muſt be ten ſhillings, and 5 times 5 as before is 25 which is one quarter, or 5 ſhillings, but in vulgar

A-

Arithmetick 10 ſhillings by 10 ſhillings maketh 100, and alſo 20 ſhillings by twenty produceth 400, and 100 is but one quarter part of 400, which is very plain, that 10 ſhillings multiplyed by 10 ſhillings can produce but 5 ſhillings, the 10 ſhillings being but a fraction or half of one pound ſtarling.

If you would multiply the eighth part of any integer by one eighth, the product will be but one 64*th* part, and one quarter of any integer being multiplyed in it ſelf, will produce one ſixteenth part.

The eighth part of one foot in length in Decimals is 125 parts of 1000 and 125 multiplyed by 125 will produce 15625, here you are to underſtand that 125 is a Fraction, and if you count the number of figures in both ſumms, you will find them to be ſix fractions, and my product is but 5 places, therefore I muſt clear it by multiplication; firſt multiply 15625 by 12, produceth 187500, but if I cut off ſix places I ſhall have nothing left, then multiply 187500 by 8 and the product will be 1500000, now I can cut off ſix places to the right hand, and I ſhall have 1 to the left hand which is one eighth, and the 5 on the right hand is half an eighth, which is one 64*th*. of one foot in length, as may be thus proved; multiply 12 by 8, produceth 96, for the eights in one foot, then add a Cypher to 96 and divide it by one and a half, and the

quotient will be 64, and therefore one eighth, and a half is one 64th. part of a foot.

This may be done by vulgar Arithmetick thus, one eighth of 12, is one inch and a half, and one inch and a half will be 12 eights, and 12 by 12 is 144, and the eights in one foot is 96 multiplyed by 96 produceth 9216, and 9216 divided by 144 the quotient will be 64, which proveth that one ſixteenth multiplyed in it ſelf will produce one ſixty fourth part.

What hath been done by the parts of a foot may be done by Engliſh Coyn; as thus, half a crown is one eight of a pound ſtarling, one eight multiplyed by one eight, will produce one 64th. part, in decimals the number anſwering to one eighth is 125, which produceth as before 15625 and this ſumm multiplyed by 20 the product will be 312500, then if I cut off ſix places for my firſt ſix fractions, there will remain nothing to the left hand, therefore it cannot produce one ſhilling, then multiply the laſt ſumm by 12 and it will produce 3. 750000, then I can cut off ſix places to the right hand, and leave a 3 to the left hand which is 3 pence, then multiply 750000 by 4, and the product is 3. 000000, then cut off the ſix Cyphers, and the 3 remaining to the left hand is 3 farthings and three pence three farthings is one 64th. part of a pound ſtarling, which may be proved

ved thus, 20 ſhillings is 240 pence, and 240 pence divided by 64, the quotient is 3 pence 3 farthings, for a proof of the work.

But if you would work this by vulgar Arithmetick, you may put one eight into pence, which will be 30 pence, and 30 by 30 is 900, and 240 by 240 is 57600 and 57600 being divided by 64, the quotient will be 900, which proveth that one 64*th*. part of 57600 is 900, then to find how much money one eighth of one pound multiplyed in it ſelf will produce, you may by theſe numbers preſently find it by the rule of proportion, as 57600 is to the number of pence in one pound 240 ſo is 900 to 3 pence 3 farthings.

And in the multiplying of any quarter by a quarter, the product will be one ſixteenth, thus one quarter of a foot in decimals is 25 parts of 100, and 25 multiplied by 25 produceth 625, and my fractions are of four places, and this is but three, then multiply 625 by 12 produceth 7500, therefore it will not be one inch, for when four places are cut off to the right hand there will not be any remain to the left hand, then multiply 7500 by 8, and that product will be 6. 0000, then cut off the four cyphers to the right hand and there will remain 6 to the left hand which are 6 eights of one inch, and ſo much is the product of one quarter of a foot, multiplyed by a quarter of a foot, which will be but 6 eights of

one

one inch, and one ſixteenth part of one foot in length is 6 eights, as you may prove thus, the eights in one foot is 96, which divided by 6 the quotient is 16, for the parts of one foot, for 6 eights is one 16*th.* part of a foot, and alſo if you divide 96 by 16, the quotient is 6, ſo it is proved both waies.

This quarter of a foot by a quarter of a foot, may preſantly be done by vulgar Arithmetick, 3 inches is one quarter of a foot in length, and 3 times 3 is 9, and 12 times 12 is 144, then divide 144 by 9 and the quotient is 16, which proveth that one quarter multiplyed, maketh but one ſixteenth of the whole either in the length or on the flat, for as 144 is to 12 ſo is 9 to 6 eights of one inch, which is one ſixteenth of the length and is the proper product multiplyed.

This may be done in Engliſh Coyn, for one quarter of one pound ſtarling is 5 ſhillings, or 60 pence, which being multiplyed in it ſelf will alſo produce one ſixteenth, which is 15 pence, for in decimals one quarter is 25, and 25 multiplyed by 25 produceth 625 which is 0625 parts of 10000 of one pound, and if you multiply 0625 by 16, the product will be 10000, which proveth that 625 is one 16*th.* of 10000, or if you divide 10000 by 625 the quotient will be 16.

This Fraction may be cleared by multiplication as before directed, or by the rule of

of proportion, thus, as 10000 is in proportion to the number of pence in twenty ſhillings, ſo is 625 to 15 pence, the number of pence deſired, to anſwer to 0625 parts of 10000, ſo ſuppoſing one pound to be divided into ten thouſand parts, and the like may be done with all other parts or fractions leſs than unity.

This or any other may be done by vulgar Arithmetick, if you multiply 5 ſhillings by 5 ſhillings, the product will be 25, and if you multiply 20 ſhillings by 20 ſhillings, the ſumm will be 400, then divide 400 by 25, and the quotient will be 16, for the parts of a pound, and 400 divided by 16 the quotient will be 25, for one 16*th.* of 400, or you may multiply 60 pence by 60 pence, and the product will be 3600, then multiply 240 the number of pence in 20 ſhillings, and that ſumme will be 57600, then divide 57600 by 3600, and the quotient is 16, which is the parts of one pound that one quarter multiplyed in it ſelf will produce, and you may alſo divide 57600 by 16, and the quotient will be 3600, which proveth that 3600 is one 16th part of 57600, which is the number of pence in 20 ſhillings ſquared, now I hope I have ſufficiently proved, that one fourth multiplied by one fourth, will produce but one ſixteenth.

And you may find the number of pence an-

anſwering thereunto by the rule of proportion, as 57600 is in proportion to 240, ſo 3600 to 15 the number of pence deſired, this I hope will be ſufficient to ſatisfie all perſons in the multiplication of fractions.

SECT. II.

Shewing how ſeveral queſtions may be reſolved by Multiplication, where one comes in the firſt place, and by Diviſion where one comes in the third place called the Rules of Practice.

IF one Foot of Purbick ſtone coſt 7 pence half penny, what will 357 foot coſt, this may be done ſeveral waies, but I will ſhew you two of them, and firſt by decimals, take out of the table of Engliſh coyn in my decimal Arithmetick in page 26 the decimal anſwering to 7 pence half penny, which is 02125 then multiply 03125 by 357 and the product is 11, 15625 and five places cut off towards the right hand, for the five places you took out of the table there will remain a 11 to the left hand, which is a 11 pounds, and the five figures cut off multiplyed by 20 is 3, 13500, then cut off five places more, and there will remain 3 to the left hand, which is three ſhillings, and what remaineth to the right hand is 12500 which multiplyed by 12 produceth 1. 50000, and 5 places cut off more to the

the right hand, their will remain to the left hand one penny, and what remaineth multiplyed by 4 and 5 places cut off vvill leave 2, which is tvvo farthings, then the price of 375 of any thing, at 7 pence half penny a foot, is a 11 pound 3 ſhillings 1 penny and 2 farthings, I have been very large and plain in this, that I may be the ſhorter in things of the like nature.

You may do this vvithout the help of the Decimal table thus, multiply 357 by 75, and the product vvill be 2677. 5. cut off one for the fraction towards the right hand, and what remaineth to the left hand is pence, and the 5 cut off is 5 tenths of a penny, which is one half, or a half penny, then divide 2677 by 12, and the quotient is 223 and one remains vvhich is one penny, then cut off the 3 to the right hand which is 3 ſhillings, then there will remain to the left hand 22 which you muſt take the half of vvhich is a 11 and is pounds, and the price of the 357 foot, yards, paces, perches or pounds, or vvhat other things you have occaſion to caſt up, the price vvill be as before by the former rule a 11 pound three ſhillings 1 penny and 2 farthings for in the caſting up of any ſuch like thing it will be convenient to do it two vvaies to prove the truth thereof. If one pound of Currants coſt three pence three farthings, vvhat ſhall 5 hundred, one quarter and 17

pound

pound coſt; here you are to underſtand that every hundred vveight is 112 pound, and uſually 16 pound Tare is allowed to every 112 pound weight, firſt put the hundreds into pounds by multiplying 112 by 5 which makes 560, unto which add one quarter vvhich is 28 pound, and the 17 pounds which maketh 585 ſingle pounds, then to find the tare anſwering to 585 vvork by the rule of proportion, as 121 is in proportion to 16, ſo is 585 to 84 almoſt, or if you multiply 585 or any other number of pounds by 134, and cut off three places tovvards the right hand, what remaineth to the left hand is pounds to be abated for tare, as in this queſtion, if 84 be taken from 585 there will remain but 501 for the number of pounds to be paid for. Then take from the before mentioned table the decimal anſwering to 3 pence and three farthings vvhich is 015625, and this multiplyed by 501 produceth 7.828125 and this cleared as you did the firſt vvill bring forth 7 pound 16 ſhillings 6 pence and 3 farthings, for the price of 501 pounds of Currants.

But if you will anſvver this queſtion vvithout the help of the decimal table of coyn, then you muſt multiply 501 by 3.75 (which is 3 pence and three quarters of one penny) and the product is 1878 pence and 75 parts of 100 of one penny, which being divided by 12 the quotient is 156 ſhillings and 6 pence three

three farthings remains, which is juſt the ſame with the former; for a proof.

If one foot of Timber coſt 13 pence half penny, what vvill 7 Load and 23 foot coſt, you are to underſtand that 50 foot is one Load, and 7 fifties is 350, one to which add 23, maketh 373 foot for the vvhole quantity, then take from the Table of Engliſh Coyn the decimal of one ſhilling vvhich is 05, and the decimal of one penny and half penny which is 00625, and add them together and they vvill make 05625, and 05625 multiplyed by 373 produceth 20. 98125, and this cleared is 20 pound 19 ſhillings 7 pence half penny, which is the price of the Timber deſired.

This may be performed without the decimal table by multiplying 373 by 13. 5. and the product is 5035. 5. which divided by 12 the quotient is 419 and 7 pence half penny remaineth, and the ſumme vvill be the ſame as before.

If 357 Foot, yards or Perches coſt a 11 pound 3 ſhillings 1 penny and 2 farthings, vvhat ſhall one foot, yard or perch coſt, (as the rules before going were done by multiplycation, this and them that followv muſt be done by diviſion) firſt in the table of Engliſh Coyn find the decimal anſwering to three ſhillings and 3 half pence, vvhich is thus, for 3 ſhillings is 15, and for 3 half pence is 00625 added

added together is 15625, then place a 11 on the left hand thereof, and the ſumm will ſtand thus, 11. 15625, as in the firſt queſtion, then divide 11. 15625 by 357 and the quotient is 03125, which multiplyed by 20. produceth 062500 and then multiplyed by 12 yieldeth 7. 50000 the 7 is pence, and the 5 next is 5 tenth parts of one penny or 2 farthings, for the price of one foot, yard or Perch, 7 pence 2 farthings, you may do the like in all others.

Hovv to perform the ſame vvithout the help of the Table of Engliſh Coyn, firſt reduce a 11 pound 3 ſhillings into pence, and unto it add the one penny and the half, thus 240 pence is one pound, a 11 times 240 is 2640 and 3 ſhillings is 36 pence, and one penny is 37, vvhich added to 2640 makes 2677.5 to vvhich add the half, then divide 2677.5 by 357, and the quotient is 7, and the remainder is 178, one to vvhich add the 5 to the right hand that it may ſtand thus 1785, then divide again by 357 and the quotient vvill be five more, but the 5 is but a decimal fraction or a half of one penny, ſo then the price of one foot, yard or perch, vvill be found to be 7 pence half penny as it was in the laſt, vvhich is a ſufficient proof of the vvork.

If fifty and one pound of Currants coſt 7 pound 16 ſhillings and 6 pence three farthings, what

what ſhall one pound coſt, the decimal of 16 ſhillings ſix pence 3 farthings, by the table of Engliſh coyn, is 828125, and to it place the 7 to the left hand, and it will ſtand thus 7. 828125, and this divided by 501 the quotient is 015625, which cleared as before directed, will produce 3 pence 3 farthings for the price of one pound of Currants.

And to work this without the help of the Table, reduce the money into pence, which will be 1878 pence, and unto it place 75 to the right hand, and it will ſtand thus 1878, 75, and this divided by 501 with two Cyphers placed on the right hand, for to ſupply the place of the two fractions, and the diviſor will be thus 50100 and the quotient will be 3, 75, of 3 pence 3 farthings, as a proof for the former.

If 373 foot of Timber coſt 20 pound 19 ſhillings 7 pence 2 farthings, what is the price of one foot, which in decimals from the Table will be thus 20, 98125, and it divided by 373 the quotient will be 05625, and this fraction cleared will yield 1 ſhilling 1 penny and 2 farthings for the price of one foot of Timber.

You may work this without the help of the Table, by reducing the pounds and ſhillings into pence, and adding the 7 pence to that ſumme, and a 5 to the right hand thereof for the half penny, & they will ſtand thus 5035, 5

which divided by 373 the quotient is 13, 5, which is 13 pence and 2 farthings, the ſame with the former.

SECT. III.

Shewing a plain and eaſy way of extracting the ſquare Root, almoſt as eaſy as diviſion, to one that can divide readily without cancelling.

FIrſt it will be neceſſary for him that learneth to extract the ſquare Root, to chooſe out ſome convenient number, and ſquare it, which is no other than multiplying in it ſelf, as ſuppoſe 33 be thought a convenient number, then multiply 33 by 33 produceth 1089 for the ſquare thereof.

And here note that any number that is multiplyed in it ſelf, that product is the ſquare of the number multiplyed, and the number that is multiplyed is called the root of that number, as thus, 2 is the root of 4 and 4 is the ſquare of 2, for 2 times 2 maketh 4, and 3 is the root of 9, and 9 is the ſquare of 3, and 4 is the root of 16, and 16 is the ſquare of 4, for you can have no other ſquare root in 16 but 4, for that being multiplyed in it ſelf produceth 16, and 5 multiplied in it ſelf makes 25, and therefore 5 is the root of 25, and 25 is the ſquare of 5, ſo in the number 33 the

ſquare

ſquare thereof is 1089, and 33 is the root of 1089 by reaſon 33 multiplyed in it ſelf produceth 1089 the multiplying of any number in it ſelf produceth the ſquare thereof.

The manner of extracting the ſquare root is thus, having a ſquare number given as 1089 to find or extract the root thereof, firſt you are to mark the figures with tittles at the top, alwaies beginning over that figure next the right hand ſide of the Book or Paper, and make a mark over it, then skip one and make over the next, as in theſe figures laſt before going, make a mark over 9, then skip the 8 and make a mark over the 0, as you may ſee, and ſo many marks as you make, of ſo many places will the root of that ſumme be, which here is but two; firſt inquier the greateſt root in 10, which reacheth to the firſt mark, and I find 3 to be the greateſt root, for 3 times 3 is 9 then place 9 under 10 and take 9 from 10 and there remaineth 1, then bring down the two figures belonging to the next mark, and they will ſtand as in the Margent 189, place 3 in the quotient and double it which is ſix, then ſet ſix under 8, and enquire how many times you can have 6 in 18, which is 3 times, then put 3 in the quotient and 3 under 9, to the right hand of ſix, which will be 63, then multiply 63 by the 3 laſt put in the quotient and it makes

1089	(33
9	
189	)
63	
189	

189, which being ſubſtracted from the figures above 63 there will remain nothing, and the ſquare root is found of 1089 to be 33.

To find the ſquare root to three places, the number given is 127449; which you muſt mark as in the margent, and the greateſt root in 12 is 3, which place in the quotient and ſquare it and ſet it under 12 and 9 from 12 leaves 3 underneath, then bring down 74 and place on the right hand thereof, then double the 3 in the quotient which is 6, and place it under 7, and ſay how many times 6 in 37, which 1 can have ſix times, and there wil remain but 1, and I cannot have 6 times 6 in 1, therefore I muſt take it but 5 times and place 5 in the quotient, and 5 on the right hand of 6 to make it 65, then multiply 65 by the 5 in the quotient, and it makes 325 taken from 374 remaineth 49, then bring down the next two figures and put on the right hand of 49 and they will ſtand thus 4949, then double the quotient which is 35 and it makes 70 which muſt ſtand under the middle 9 and 4 then ſay how many times 7 in 49, which I find may go 7 times by reaſon the next place is a Cypher, then I put 7 in the quotient and 7 on the right hand of 70, and multiply 707 by the 7 in the quotient, and it produceth

```
127449(357
9
374)
 65)
325)
 4949
 707
 4949
```

4949

4949, which taken from 4949 remaineth nothing, and the root found.

How you may extract the square root of a surd number, and supply it with a decimal by adding of pairs of Cyphers as in the margent; first inquire the greatest root in 7, which is two place 2 in the quotient and its square under 7, 4 from 7 leaveth 3, to which bring down 85 makes 385, double the quotient and put it under 8, then say how many times 4 in 38, it will go but 8 times, place 8 in the quotient, and 8 on the right hand of 4, then multiply 48 by 8, and it makes 384, which Substracted from 385, leaveth 1, then add two Cyphers to 1 and it will not go, then prick off the 28 in the quotient and put down a Cypher to begin the fraction, then add two Cyphers more and double the quotient which is 280, which makes 560, then I inquire how many times 5 in 10, and I must take it but once, then substract 5601 from 10000 and there will remain 4399, then add 2 Cyphers to 4399 and it will stand thus 439900, then double the quotient and it makes 5602, then

```
785 (28 : 0178
4
385)
 48)
384)
  10000)
   5601)
   439900)
    56027)
   392189)
    4771100)
     560348)
     4482784)
rema. 288316
```

I say

I ſay how many times 5 in 43, and I find it go but 7 times then place 7 in the quotient, and on the right hand of 5602 which will ſtand thus, 56027, which being Multiplyed by the 7 in the quotient, maketh 392189, and this taken from 439900, there will remain 47711, to which add two Cyphers, makes 4771100, and the double of the quotient is 56034 for my new divizor, then I inquire how many times it will be had therein, and I find it 8 times, which I place in the quotient for the neareſt root, for ſo many places is 28: 0178 parts of 10000, which is neer enough the truth for any uſe.

And for thoſe that have much occaſion to make uſe of the ſquare Roots, I have them ready for the *Preſs*, from one to fifteen hundred, both ſquare numbers and Surds, to the thouſand part of Unity, with the ſeveral uſes therof, ſufficiently Explained, by many Examples; a thing not yet Publiſhed in any Language; with the Practical part of Surveying, wherein there are ſeveral things declared after a plain and eaſy Practical manner, with the uſe of the *Croſs Staff* in Surveying, and finding Acceſſable and Inacceſſable Diſtances, which is a thing known to few or none in *England*, but who have been my Scholars.

With a very exact way of caſting up a field without Plotting of it, far more exact than

Scale

Scale or Compaſs can lay it down.

But if there ſhould be an occaſion of Plotting of the field, yet it may be caſt up more certainly by the Chain Lines themſelves, than by any Scale and Compaſſes, although the Plot be very large, and eſpecially the perpendicular ſets off, for ſome of them are very ſmall: The way of doing it hath not yet been publiſhed; alſo there is a Table Calculated to Degrees, and the hundredth part of a degree for the taking of Angles with the Chain, to the tenth part of every Link thereof, 33 foot anſwering to the Semediameter, which is much larger then any Surveying Inſtrument, with the deſcription of convenient Scales, to lay down any Plott from 4 Perches in one inch to 30 or 40 to every other Perch, and the deſcription of a Circumferenter, to Survey and take Altitudes with, which will be but part of a Theodelite there deſcribed, ſuch an one that hath not been yet made, and more convenient for uſe and Exactneſs than any other inſtrument yet made uſe of.

The Geometrical part of this Book is much performed by the Tables of the Square roots, for the reducing one figure into another form, as a Trapezia, a Triangle, a Circle, or any Mult-angled figure, into a Geometrical ſquare, or a Right Angled Triangle, The book will be but ſmall, fit for a Pocket-Companion.

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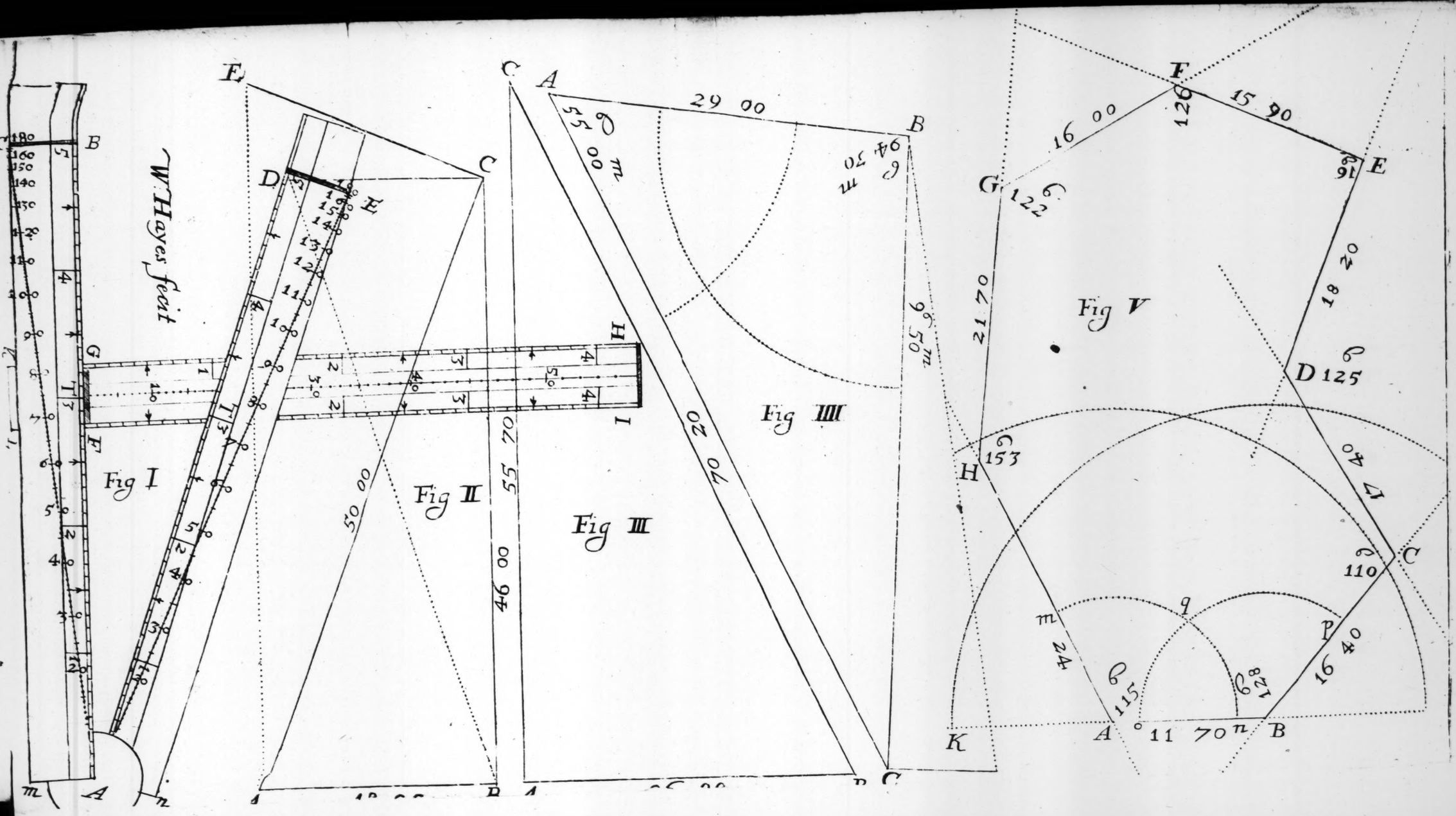
Drawing of Ovals at any convenient Angle, and to juſt touch any length, and breadth of any Parralellagram, or oblong ſquare given.

Any Gentleman or others, that have occaſion to have any Land truly meaſured in *England* or *Wales*, and a fair Plott thereof made, may have it exactly performed by the Author hereof.

Any perſon that pleaſeth may be taught at their convenient houres at their own dwellings, or at any place appointed about the City of *London* or *Weſtminſter*, or at my own houſe at ſuch times as ſhall be appointed, either by the week or month, and when we know one another in Learning, they may agree for ſome certain price for what they would learn.

FINIS.

MVSEVM BRITAN NICVM


W. Hayes fecit
Fig I
Fig II
Fig III
Fig IIII
Fig V